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PICATINNY ARSENAL

TECHNICAL DIVISION

TECHNICAL REPORT

STABILITY OF ROCKET PROPELLANTS

SUBJECT: Effect of Metals on Double-Base Propellants

PROJECT NO. TU2-4C **REPORT NO.** 1

PREPARED BY: J.E. Abel, A.S. Ribnick, E. McAbee **DATE** 28 July 1951

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6 STABILITY OF ROCKET PROPELLANTS.

Effect of Metals on Double-Base Propellants [U]. 8

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Project No. TU2-4C

9 Report No. 1

Picatinny Arsenal Technical Report No. 1822

11 28 July 1951

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Agency Performing Work: Picatinny Arsenal, Dover, New Jersey

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Project No.: TU2-4C

DOA Priority Designation: 2A

Project Title: Stability of Rocket Propellants - Effect of Metals on Double-Base Propellants

OBJECT

To determine the effect of metals and plastics on the stability and physical characteristics of double-base propellent powders.

SUMMARY

Tests have been made to determine the degree of reactivity between the M2, M7, M13 and T7 Propellants and aluminum, magnesium, stainless steel, tin-plated steel, zinc-plated steel and phenol formaldehyde varnish-coated sheet steel. Two sets of test conditions were employed. First, ground mixtures of propellant and metal or phenol formaldehyde varnish were stored for six months at 50°C and ambient humidity. Second, grains of each propellant were stored in contact with each of the surfaces mentioned for six months at 32°C and 90% Relative Humidity.

Both 120°C Heat Test and 90°C Vacuum Stability Test results indicate that no decomposition occurred during storage of the ground mixtures.

Microscopic examination of the propellent grains indicates the following: (1) the propellants, in order of decreasing compatibility, are: M7, M13, M2 and T7, and (2) the contact surfaces in order of decreasing compatibility are: stainless steel, phenol formaldehyde varnish, aluminum, tin, zinc and magnesium.

The standard JAN compression test did not show any significant difference for grains of any one propellant stored with any of the contact surfaces.

CONCLUSIONS

The degree of reactivity between propellent grains and contact surfaces was determined by microscopic examination.

On this basis, aluminum, stainless steel and this particular phenol formaldehyde coating are less reactive than tin, magnesium and zinc.

RECOMMENDATIONS

It is recommended that authorization be given for the use of aluminum or phenol formaldehyde varnish-coated steel as liners for containers for the storage of propellants.

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INTRODUCTION:

1. The Department of the Air Force has reported instances of physical deterioration of double-base propellants in contact with their storage containers (Ref A). Observations of reduction in tensile strength, decrease in stability and non-uniformity of the contact metal surfaces have been reported. The British have reported deterioration and embrittlement of double-base powder stored in zinc-coated containers (Ref B). Information was, therefore, desired on the type of metal or metal coating which would be most effective for use as containers or liners for containers for the storage of double-base propellent powders.

2. At the request of the Office, Chief of Ordnance (Ref C), all previous pertinent research was reviewed and an investigative program prepared which was designed to provide additional and more complete information on this subject. This research program comprised an investigation to study the effect produced on the M2, M7, M13 and T7 propellants when stored in contact with aluminum, magnesium, stainless steel, tin-plated steel, zinc-plated steel and phenol formaldehyde varnish-coated sheet steel under accelerated conditions of temperature and humidity.

3. The investigation reported herein was divided into two principal parts, as follows:

a. Cylindrical grains of each propellent powder were stored in contact with each metal and plated or coated metal at 32°C (90°F) and 90% Relative Humidity. Control samples on glass under these conditions and also at desiccated humidity were studied for comparison.

b. Ground mixtures of each of the four propellent powders with each of the five metals and the phenol formaldehyde varnish, as well as controls consisting of individual samples of each propellant, metal and varnish, were stored at 50°C and prevailing humidity.

4. This report gives the detailed results of stability and physical property tests made at the end of both three and six months' storage under the above conditions. Work on this project has been concluded and no further report is to be issued.

RESULTS:

5. The results of both the 120°C Heat Test and the 90°C Vacuum Stability Test indicated that no significant reaction occurred between ground, intimate mixtures of any of the propellants with any of the metals or the varnish during storage for six months at 50°C and ambient humidity. Initial test values and those obtained at the end of three and six months' storage are given in Table II.

RESULTS: (contd)

6. Microscopic examination of the propellants and metals after storage for three months at 32°C and 90% Relative Humidity indicated the following:

a. The propellants, in order of decreasing compatibility are: M7, M13, M2 and T7.

b. The contact surfaces, in order of decreasing compatibility are: stainless steel, phenol formaldehyde varnish, aluminum, tin, zinc and magnesium.

The same relative order of propellants and contact surfaces were noted at the end of six months' storage at 32°C and 90% Relative Humidity. However, the adverse effects were all generally accentuated. The results of the microscopic examinations made of the propellent grains and contact surfaces stored under this condition are given in Tables III, IV, VI and VII.

7. Microscopic examination of the propellants and contact surfaces after three and six months' storage at 32°C and desiccation indicated very little reaction to occur, except the case of T7 propellant stored on zinc. This latter combination did appear to undergo some reaction. The results of all the microscopic examinations made for this storage condition are given in Tables V and VIII.

8. Photographs representative of the changes noted by microscopic examination are included, Figures 1, 2, 3, 4 and 5.

9. Standard JAN compression tests on samples stored at (a) 32°C and (b) 32°C and 90% Relative Humidity (Tables IX - XII and Figures 6 - 13 incl) showed the following:

a. No one contact surface showed a particularly deleterious effect on any propellant. Surface effect differences noted in microscopic examinations were not generally reflected in compression test values. One exception to this was the case of the T7 propellant. In this case, the values for the work to produce failure were somewhat lower for those grains which had been stored with magnesium, tin and zinc (Figure 13).

b. Neither desiccated nor 90% Relative Humidity storage with any of the different contact surfaces had any apparent or uniform effect on the compressive properties of the M2 propellant.

DISCUSSION OF RESULTS:

10. As compared with previous investigations (Ref D) of this nature, the study reported herein had several different features. First, the use

DISCUSSION OF RESULTS: (contd)

of dynamic test conditions for the storage of the propellent grains. This was accomplished by employing a Tenney Temperature-Humidity Test Chamber to maintain the desired conditions of temperature and humidity within one per cent, with uniformity of chamber conditions assured by continuous air circulation. Previous studies have been conducted principally under static chamber conditions which have not proven uniform. Secondly, mixtures of ground propellant and ground metal were made on the basis of equal areas of surface contact as calculated from the respective particle sizes. Previous studies have been made principally on an equal weight basis which did not result in valid comparisons in cases where the densities and particle sizes of propellant and metal differed significantly.

11. Mixtures of ground propellant and metal were used in this investigation to establish, by the use of elevated temperature storage, whether any reaction would occur. Examination of the data given in Table II would indicate that under these storage conditions, no change took place. Further, these tests showed no decomposition that could be correlated with the results of visual and microscopic examination of the propellent grains.

12. The detailed microscopic examination of the propellent grains are given in Tables III through VIII and need little explanation. It should be noted that under the conditions of high humidity, corrosion of both propellant and metal was very evident even after only three months. Continued storage for an additional three months only served to accentuate the corrosion process. The T7 propellant was the most affected which may be due to its nitroguanidine content. Undoubtedly, under prolonged storage at these conditions, this propellant would have eventually deteriorated to the point of complete physical breakdown. This might ultimately happen to other propellants also, but in the case of the T7, the process would be more rapid. While the surface effects were not reflected by changes in the compressive properties, it is considered likely that this corrosion process would adversely effect the physical properties of the propellant, should the conditions of high temperature and humidity prevail for prolonged periods of time.

13. The physical property data, in a sense, were somewhat disappointing in that no correlation was found to exist between the surface effects noted by microscopic examination and the compressive properties of the grains. Only in one case, that of the T7 propellant, was there any evidence of a possible correlation (see Figure 13). Values for "work to produce failure" plotted against storage conditions gives some slight evidence of the deleterious effect of zinc, magnesium and tin, in that the values for this property are somewhat lower for the grains of T7 propellant stored in contact with these three metals. The values at 1% compression for all propellants are not graphically illustrated since the largest experimental

DISCUSSION OF RESULTS: (contd)

error would occur within the early stages of the compression. A study of the data obtained gives no complete correlation regarding the effect of storage materials on the compressive properties. Likewise, no rule can be made regarding the effect of desiccated and 90% Relative Humidity storage on the physical properties of the grains. However, in the cases of stress at 5% compression of the M7 and M13 and stress at rupture of the T7 propellants, there is a decided increase in stress after storage at 90% Relative Humidity. This would seem to indicate some effect of the high humidity on these propellants. This raising of stress is contrary to the results usually obtained, as water normally acts as a plasticizer and as such increases the deformation and lowers the strength of the materials. While visual examination of the grains revealed variable degrees of corrosion at the surface of the propellants, this had not penetrated deeply enough to have any appreciable effect on the compressive properties. It is probable that the compressive test will not indicate the effects of surface corrosion, but would be more indicative of the functioning of the grain as a unit.

14. Work similar to that reported herein has also been done at the Naval Powder Factory (Ref D). Part of this research embraced a study of the effect produced on the physical properties of propellent grains stored in contact with various metal surfaces. Specifically, it involved a study of grains of 3"/50 cal "NH" and Cordite N propellants stored for six months on steel, brass, zinc-coated steel, zinc-coated steel-chromate treated steel and steel coated with phenolic lacquer at three different conditions; namely, (a) 92°F and ambient humidity, (b) 150°F desiccated and (c) 150°F and 100% Relative Humidity. The last two conditions were much more severe than those used in the present study and any degradation would be more accentuated by these conditions than those used in this report. The grains of "N" and "NH" were severely affected, particularly under the conditions of high temperature and humidity and stored in contact with zinc and brass. The NPF used the side impact test for brittleness to establish effects on physical properties (Ref F). This is in contrast to the compressive test used in this program. The conclusion reached in the NPF report was that, of the contact surfaces tested, a phenol lacquered steel had the least effect on the propellants.

15. In view of all the above, it would seem advisable to use in practice those metals or protective coatings which show the least effect on propellants. From the observations made herein, stainless steel, aluminum and phenol formaldehyde varnish-coated steel are indicated to be less reactive than zinc, magnesium and tin. On the basis of both studies, it is recommended that consideration be given to the use of the three best materials as liners or protective coatings for containers where such are to be used for the storage of propellants for prolonged periods of time,

DISCUSSION OF RESULTS: (contd)

possibly under extreme climatic conditions. Stainless steel is now being employed as liner for propellent containers for small arms propellants.

EXPERIMENTAL PROCEDURE:

16. The propellent powders used (see Table I) in the mixtures were ground in a hand grinder to pass through a 12 mesh sieve. Magnesium, aluminum, zinc and tin were atomized to approximately the same size, 168 microns, 145 microns, 124 microns and 171 microns, respectively, as determined by the air permeability method (Ref E). The stainless steel was obtained in 75 micron size. The phenol formaldehyde varnish was prepared by painting this material on polyethylene sheets and scraping it off. A final drying of the varnish was made in vacuum. The mixtures of ground propellant and metal were made on an equal surface area basis according to the calculations of Gooden and Smith (Ref E).

17. The mixtures of ground propellant and metal, subjected to 50°C and ambient humidity, were stored in loosely cork-stoppered glass bottles in electrically heated, thermostated ovens, Model 1250, manufactured by the Precision Scientific Company.

18. The ground mixtures were subjected to 120°C Heat Tests and 90°C Vacuum Stability Tests in accordance with the procedures described in Picatinny Arsenal Technical Report No. 1401, Revision 1.

19. The storage of the propellent grains was made in a temperature-humidity test chamber, Model 36TR, manufactured by the Tenney Engineering Company, Incorporated, Newark, New Jersey. The grains subjected to 32°C and 90% Relative Humidity were placed end-wise on 6" x 6" squares of metal varnish-coated metal and glass (control) in the test chamber. The grains and test surfaces subjected to 32°C and desiccated humidity were placed in glass desiccators using "Desicchlora" as the drying agent and the desiccators were placed in the same test chamber.

20. The following contact surfaces were used in this investigation:

a. Aluminum: 16 gauge, #2, half-hard
b. Magnesium: 0.156", U.S. Army Specification 57-157, Class 18, annealed
c. Stainless steel: 1/6", #5012, Type 18-8
d. Tin-plated steel: 0.0125 = 30 gauge, Type 2, Grade 2
e. Zinc-plated steel: 16 gauge, Federal Specification QQ-L-696
f. Phenol Formaldehyde Varnish, "Bakelite" XV 1657, 12½ gallon tung oil, phenolformaldehyde, Navy Specification NAVORD No. 1433, Type A. This varnish was coated on: Sheet steel: 1/6", Federal Specification QQS-11A

EXPERIMENTAL PROCEDURE: (contd)

21. The method of compression testing employed was that given in Ref G. The samples were tested under standard conditions ($77^{\circ}F \pm 2^{\circ}F$ and 50% Relative Humidity $\pm$ 2% Relative Humidity) following temperature conditioning. Compression testing was done on an Instron Tester with an adjustable speed control so that the rate of crosshead travel could be varied among specimens to give the desired 0.100 inch per minute per inch of specimen height. A sub-press and compressometer in conjunction with a Baldwin stress-strain recorder were used to assure axial loading and accurate measurement of the amount of compression (Photograph M-38451). The outside diameters and heights were measured by micrometer. However, the perforations were so small that the only satisfactory method of measurement was to insert wires of known diameters and assume this diameter to be equal to the diameter of the perforation. Due to excessive amounts of corrosion found in some of the perforations, it was felt that a microscopic determination of the diameters would be extremely difficult. The above method was, therefore, used.

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A. Department of the Air Force
O.O. 471.86/129(c), 22 January 1948.

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No 34585 (11 July 1947)
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C. O.O. 471.86/135(c), ORDBB 471.5/3387, 29 January 1948.

D. Naval Powder Factory, Technical Report No. 32, dated 10 August 1950, "Compatibility of Zinc and Other Coatings for Steel with Double-Base Propellants."

E. "Measuring Average Particle Diameter of Powders," by Gooden and Smith; Analytical Edition, Industrial and Engineering Chemistry, Volume 12, pages 479-482, 15 August 1940.

F. OSRD Report No 5592.

G. JAN Panel on Physical Properties of Solid Propellants - Method for Determining the Compressive Properties of Solid Rocket Propellants - Approved 24 January 1950.

INCLOSURES:

Tables I - XII incl
Figures 1 - 13 incl
Photograph M-38451

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TABLE I

COMPOSITION AND GRAIN DIMENSIONS OF PROPELLANTS USED

Type	M2	M7	M13	T7
Lot Number	RAD-9713	RAD-51045	SUN-18577	DP-6285
Nitrocellulose, %	76.26	54.29	57.04	20.78
Nitroglycerine + Dinitrotoluene, %	20.52	35 32	40.23	17.28
Potassium perchlorate, %	-	7.98	-	-
Barium Nitrate, %	1.54	-	-	-
Potassium Nitrate, %	0.82	-	-	-
Potassium Sulfate, %	-	-	1.61	-
Graphite, %	0.26	-	-	-
Carbon Black, %	-	1.31	-	-
Diphenylamine, %	0.60	-	0.19	-
Ethyl Centralite, %	-	1.10	0.93	5.42
Nitroguanidine, %	-	-	-	54.93
Cryolite, %	-	-	-	0.25
Total Volatiles	1.85	0.39	0.88	0.17
Height of Grain, in	3/16	3/8	7/8	5/16
Diameter of Grain, in	3/16	3/8	7/8	5/16
Tolerance, in (as measured)	± 0.005	± 0.007	± 0.009	± 0.004

REGRADING DATA CANNOT BE PREDETERMINED

TABLE II

THERMAL STABILITY DATA OF
MIXTURES OF GROUND PROPELLANT AND METAL

Propellant	Metal	120°C Heat Test: Initial Values SP min	Initial Values RF min	Initial Values EXPL min	3 months SP min	3 months RF min	3 months EXPL min	6 months SP min	6 months RF min	6 months EXPL min	90°C Vac Stab cc gas/40 hrs: 0 mos	3 mos	mos
T7	Tin	95	300+	300+	120	300+	300+	80	300+	300+	0.62	0.55	0.45
M13	"	70	300+	300+	100	240	300+	90	250	300+	0.73	1.03	0.90
M7	"	100	300+	300+	110	300+	300+	80	275	300+	0.86	0.62	0.54
M2	"	95	300+	300+	90	250	300+	100	260	300+	0.16	0.40	1.32
T7	Zinc	95	250	300+	150	285	300+	105	280	300+	0.64	0.81	0.66
M13	"	60	200	300+	105	275	300+	85	200	300+	0.49	1.00	0.85
M7	"	85	210	300+	105	280	300+	95	275	300+	0.57	0.51	0.66
M2	"	100	300+	300+	110	285	300+	85	290	300+	0.55	0.69	0.45
T7	Aluminum	70	140	300+	95	240	300+	80	180	300+	1.09	0.93	0.96
M13	"	65	210	300+	60	150	300+	65	125	300+	1.04	1.19	1.23
M7	"	70	220	300+	80	210	300+	75	150	300+	1.14	0.61	0.86
M2	"	85	220	300+	65	150	300+	70	105	300+	0.78	1.23	1.77
T7	Magnesium	100	300+	300+	90	175	300+	85	250	300+	1.38	1.28	1.19
M13	"	55	120	300+	55	125	300+	70	200	300+	1.41	1.45	1.41
M7	"	65	180	300+	95	250	300+	80	175	300+	1.27	1.31	1.14
M2	"	90	110	300+	100	210	300+	70	250	300+	1.14	1.58	1.89
T7	Bakelite	65	150	300+	65	140	300+	70	100	300+	3.32	1.08	1.27
M13	"	50	150	300+	60	130	300+	60	80	300+	3.24	1.43	1.39
M7	"	70	180	300+	65	130	300+	65	110	300+	2.71	1.03	1.19
M2	"	65	180	300+	65	145	300+	75	155	300+	3.02	1.25	1.46
T7	Stainless Steel	75	300+	300+	120	300+	300+	100	290	300+	0.69	0.64	0.56
M13	"	50	210	300+	65	210	300+	70	110	300+	0.88	0.76	0.87
M7	"	90	300+	300+	90	210	300+	100	175	300+	0.86	0.52	0.60
M2	"	80	300+	300+	95	250	300+	95	250	300+	0.68	0.91	1.05
T7	-	40	90	300+	55	105	300+	60	100	300+	2.95	3.01	3.20
M13	-	40	65	300+	55	90	300+	55	60	300+	2.99	3.87	3.95
M7	-	40	80	300+	55	90	300+	55	65	300+	2.60	2.27	2.62
M2	-	45	85	300+	50	90	300+	50	55	300+	2.67	3.79	4.06
-	Tin	-	-	-	-	-	-	-	-	-	0.22	0.15	-
-	Zinc	-	-	-	-	-	-	-	-	-	0.31	0.57	-
-	Aluminum	-	-	-	-	-	-	-	-	-	0.34	0.17	-
-	Magnesium	-	-	-	-	-	-	-	-	-	0.24	0.20	-
-	Bakelite	-	-	-	-	-	-	-	-	-	3.80	0.60	-
-	Stainless Steel	-	-	-	-	-	-	-	-	-	0.17	0.18	-

TABLE III

EVALUATION OF PROPELLENT GRAINS BY MICROSCOPIC INSPECTION AFTER THREE MONTHS' STORAGE

Metal	Storage Temperature	Relative Humidity	M2 Propellant surface	M2 Metal surface	M7 Propellant surface	M7 Metal surface	M13 Propellant surface	M13 Metal surface	T7 Propellant surface	T7 Metal surface
Zinc	32°C	90%	$B_{1,3}$	D	A	D_1	B_1	E_1	E_4	E_4
Zinc	32°C	Desiccated	A	A	B	C	A	A	A	B
Stainless Steel	32°C	90%	C_3	B	A	B	A	B	E_1	C
Stainless Steel	32°C	Desiccated	A	A	A	A	A	B	A	A
Tin	32°C	90%	D_3	D	B	B	C	C	E_5	E
Tin	32°C	Desiccated	A	A	A	A	A	A	A	A
Magnesium	32°C	90%	$D_{1,3}$	E_1	C_1	D	$D_{1,2}$	E_1	$E_{5,6}$	E_1
Magnesium	32°C	Desiccated	A	A	A	A	A	A	A	A
Aluminum	32°C	90%	$D_{3,7}$	C	A	B	A	B	$D_{1,3}$	D
Aluminum	32°C	Desiccated	A	A	A	A	A	A	A	A
Bakelite	32°C	90%	D_3	C	A	A	A	A	E_3	$D_{7,8}$
Bakelite	32°C	Desiccated	A	A	A	A	A	A	A	A
Glass	32°C	90%	$D_{1,3,7}$	A	B_9	A	B_2	A	$D_{1,3}$	A
Glass	32°C	Desiccated	A	A	A	A	A	A	A	A

Rating Code
A = Unchanged from original appearance
B = Staining, incipient corrosion
C = Slight corrosion
D = Medium corrosion, pitting, some decomposition
E = Severe corrosion, cracking of grain

Notes
1. Heavy crystal formation on surface
2. Liquid exudate
3. Perforations filled with yellow crystalline deposit
4. Deposit of amorphous yellow-brown substance
5. Base of grain is dark, red-brown, soft, expoliated
6. Radial cracking of grain
7. Numerous filaments on surface
8. Numerous long needle-like crystals
9. White crystals in the form of clusters

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TABLE IV

TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLENT GRAINS STORED FOR THREE MONTHS AT 32°C AND 90% RELATIVE HUMIDITY

Metal Surface *	Propellant Surface * A	B	C	D	E
A	M7 - Bakelite M13 - Bakelite	M7 - Glass M13 - Glass		M2 - Glass T7 - Glass	
B	M7 - S. Steel M7 - Aluminum M13 - S. Steel M13 - Aluminum	M7 - Tin	M2 - S. Steel		
C			M13 - Tin	M2 - Aluminum M2 - Bakelite	T7 - S. Steel
D	M7 - Zinc	M2 - Zinc	M7 - Magnesium	M2 - Tin T7 - Aluminum	T7 - Bakelite
E		M13 - Zinc		M2 - Magnesium M13 - Magnesium	T7 - Zinc T7 - Tin T7 - Magnesium

* Same Ratings Used as Given in Table III

TABLE V

TABULAR EVALUATION BY MICROSCOPIC EXAMINATION OF PROPELLENT GRAINS STORED FOR THREE MONTHS AT 32°C UNDER DESICCATION

	Propellant Surfaces *				
	A	B	C	D	E
Metal Surfaces *	All Others				
	M13 - S. Steel T7 - Zinc				
		M7 - Zinc			

* Same Ratings Used as Given in Table III

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TABLE VI

EVALUATION OF PROPELLENT CRAINS BY MICROSCOPIC INSPECTION AFTER SIX MONTHS' STORAGE

Metal	Storage Temperature	Relative Humidity	M2 Propellant-contact surface	M2 metal interface	M2 Propellant-exterior	M7 Propellant contact surface	M7 metal interface	M7 Propellant exterior	M13 Propellant contact surface	M13 metal interface	M13 Propellant exterior	T7 Propellant contact surface	T7 metal interface	T7 Propellant exterior
Zinc	32°C	90%	C	D	C	B	D	E	C	E	D	E	E	C
Zinc	32°C	Desiccated	A	A	A	B	C	C	A	A	B	A	B	C
Stainless Steel	32°C	90%	D	B	A	B	B	C	C	C	B	E	C	A
Stainless Steel	32°C	Desiccated	A	A	A	A	A	A	A	B	C	A	A	A
Tin	32°C	90%	D	D	E	D	D	E	C	E	D	E	E	E
Tin	32°C	Desiccated	A	A	A	A	A	A	A	A	A	A	A	A
Magnesium	32°C	90%	E	E	D	D	D	D	D	E	D	E	E	E
Magnesium	32°C	Desiccated	A	A	A	A	B	C	A	B	B	A	A	A
Aluminum	32°C	90%	D	D	C	B	C	C	B	B	B	E	D	D
Aluminum	32°C	Desiccated	A	A	A	A	C	B	A	A	A	A	A	A
Bakelite	32°C	90%	D	D	D	B	B	B	B	B	A	E	D	D
Bakelite	32°C	Desiccated	A	A	A	A	A	A	A	A	A	A	A	A
Glass	32°C	90%	D	A	A	C	A	A	C	A	A	E	A	A
Glass	32°C	Desiccated	A	A	A	A	A	A	A	A	A	A	A	A

Rating Code:

A - Unchanged from original appearance
B = Staining, incipient corrosion
C = Slight corrosion
D = Medium corrosion, pitting, some decomposition
E = Severe corrosion; cracking of grain

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TABLE VII

TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLENT GRAINS STORED FOR SIX MONTHS AT 32°C AND 90% RELATIVE HUMIDITY

Metal Surfaces (Interface) *	Propellant Surfaces *				
	A	B	C	D	E
A			M7 - Glass M13 - Glass	M2 - Glass	T7 - Glass
B		M7 - S. Steel M7 - Bakelite M13 - Aluminum M13 - Bakelite		M2 - S. Steel	
C		M7 - Aluminum	M13 - S. Steel		T7 - S. Steel
D		M7 - Zinc	M2 - Zinc	M2 - Tin M2 - Aluminum M2 - Bakelite M7 - Tin M7 - Magnesium	T7 - Aluminum T7 - Bakelite
E			M13 - Zinc M13 - Tin	M13 - Magnesium	M2 - Magnesium T7 - Zinc T7 - Tin T7 - Magnesium

* Same Ratings Used as Given in Table VI

TABLE VIII

TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLENT GRAINS
STORED FOR SIX MONTHS AT 32°C UNDER DESICCATION

Metal Surface* (Interface)	Propellent Surface * A	B	C	D	E
A	All others				
B	M7 Magnesium M13-S. Steel M13 - Magnesium T7-Zinc				
C	M7-Aluminum	M7-Zinc			
D					
E					

* Same Ratings Used as Given in Table VI

TABLE IX

COMPRESSIVE PROPERTIES OF M-2 PROPELLANT AT 32°C

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	5% Comp	50% Comp	Rupture	Work ft lbs/in³ to Produce 50% Comp
Control							
Average	0	0	3640 (5)	6540 (5)	17100 (5)		376 (5)
Range			4130-2790	6730-6410	17400-16800		385-358
Zinc							
Average	3		2750 (7)	6420 (7)	17100 (7)		385 (7)
Range			4020-1540	6760-5660	18300-16500		398-370
Average	6		2210 (7)	6550 (7)	17000 (7)		372 (7)
Range			4330-1000	7030-5670	18600-15400		396-349
Average		3	2070 (7)	5840 (7)	16600 (7)		350 (7)
Range			3620-1130	6160-5540	20100-15300		390-327
Average		6	2250 (7)	7540 (7)	17900 (7)		412 (7)
Range			2770-1900	8130-6970	446-388		446-388
Stainless Steel							
Average	3		3120 (7)	6760 (7)	16100 (7)		366 (7)
Range			4290-2220	7790-5880	17500-14700		387-347
Average	6		3090 (7)	7390 (7)	18000 (7)		408 (7)
Range			3920-2000	7940-6760	19600-16500		435-404
Average		3	1450 (7)	5870 (7)	16100 (7)		348 (7)
Range			2560-1090	6160-5540	17100-15300		363-339
Average		6	2560 (7)	7030 (7)	17900 (7)		412
Range			2770-1900	8130-6970	19700-16800		446-388
Tin							
Average	3		2970 (7)	6950 (7)	17000 (7)		382 (7)
Range			4330-1780	7840-5940	17300-15800		415-368
Average	6		1950	6740	16700		378
Range			3270-1540	7320-6230	17600-16100		413-354
Average		3	1700 (7)	6000 (7)	16400 (7)		350 (7)
Range			2380-1180	6420-5020	18100-15300		373-318
Average		6	2350 (7)	6320 (7)	16100 (7)		356 (7)
Range			4290-1250	6940-5710	17300-14800		386-329

(Figures in parenthesis are the number of observations)

TABLE IX (contd)

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desic-cated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Work ft lbs/in^3 to Produce 50% Comp
Aluminum							
Average	3		2520 (7)	6760 (7)	17400 (7)		376 (7)
Range			3930-1160	7230-5480	19700-16200		407-345
Average	6		2270 (7)	6780 (7)	17300 (7)		385 (7)
Range			3800-1580	7170-6400	18600-16200		404-366
Average		3	2980 (7)	5970 (7)	15900 (7)		351 (7)
Range			3830-1220	6600-5210	17600-14100		390-327
Average		6	2780 (7)	6510 (7)	16500 (7)		365 (7)
Range			4420-1470	6840-6030	18200-15400		381-345
Magnesium							
Average	3		2800 (7)	6970 (7)	17800 (7)		396 (7)
Range			3760-2030	7210-6670	18700-16900		409-376
Average	6		2320 (7)	6680 (7)	16800 (7)		376 (7)
Range			3960-1570	7460-6090	19900-15400		398-352
Average		3	1870 (7)	6280 (7)	16500 (7)		361 (7)
Range			2490-1110	6600-5830	17200-16000		375-342
Average		6	2840 (7)	6530 (7)	16500 (7)		369 (7)
Range			4410-1600	6960-5850	18200-15100		393-350
Varnish							
Average	3		3800 (7)	6620 (7)	17000 (7)		378 (7)
Range			2980-4110	6870-6480	17900-15900		366-394
Average	6		1880 (7)	6640 (7)	17100 (7)		386 (7)
Range			2440-1110	7310-5330	18300-16200		412-358
Average		3	1750 (7)	5740 (7)	16100 (7)		341 (7)
Range			2030-1390	6080-5460	17600-15000		355-330
Average		6	2680 (7)	6610 (7)	16800 (7)		374 (7)
Range			4550-1170	6960-5850	18500-15200		390-354

(Figures in parenthesis are the number of observations)

TABLE IX (contd)

Storage Material	Storage Period, mos: 90% RH	Storage Period, mos: Desic-cated	Stress in psi at: 1% Comp	5% Comp	50% Comp	Rupture	Work ft lbs/in^3 to Produce 50% Comp
Glass							
Average	3		2940 (7)	6580 (7)	17200 (7)		377 (7)
Range			5180-1370	6990-5980	18100-16000		399-351
Average	6		2580 (7)	6830 (7)	17800 (7)		391 (7)
Range			4050-1500	7650-5700	19000-16000		435-336
Average		3	3430 (7)	6370 (7)	17200 (7)		370 (7)
Range			4270-3200	6730-6180	17900-16300		393-358
Average		6	2700 (7)	6750 (7)	17600 (7)		389 (7)
Range			4580-1370	7250-6040	20200-15700		444-350

(Figures in parenthesis are the number of observations)

TABLE X

COMPRESSIVE PROPERTIES OF M-7 PROPELLANT AT 32°C

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 to Produce 50% Comp	Work ft lbs/in^3 to Produce Rupture
Control									
Average	0	0	1020	1630	6040			123	
Range	0	0	1170-926	1680-1580	6470-5530			127-119	
Zinc									
Average	3		1280 (7)	2170 (7)	6580 (1)	6380 (6)	48.4 (6)	145 (1)	138 (6)
Range			1410-1030	2250-2120	6580-6580	6570-6230	49.8-47.7	145-145	144-132
Average	6		1060 (7)	2740 (7)	7380 (1)	7520 (6)	49.3 (6)	171 (1)	171 (6)
Range			1400-914	2810-2670	7380-7380	7830-7170	49.8-48.0	171-171	178-164
Average		3	1040 (7)	1610 (7)	6110 (6)	6040 (1)	49.5 (1)	124 (6)	118 (1)
Range			1320-428	1650-1560	6300-5570	6040-6040	49.5-49.5	130-118	118-118
Average		6	960 (7)	1760 (7)	6550 (7)			131 (7)	
Range			1280-505	1840-1660	6920-6390			137-126	
Stainless Steel									
Average	3		1290 (7)	2280 (7)	6590 (1)	6500 (6)	47.8 (6)	152 (1)	141 (6)
Range			1710-1190	2380-2170	6590-6590	6960-5890	48.1-47.2	152-152	151-135
Average	6		1170 (7)	2950 (7)	8240 (1)	7360 (5)	47.6 (5)	180 (2)	173 (5)
Range			1700-694	3020-2860	8240-8240	7940-6670	49.4-45.9	180-179	180-166
Average		3	1090 (7)	1640 (7)	6170 (3)	6160 (4)	48.9 (4)	128 (3)	121 (4)
Range			1390-692	1730-1550	6480-5790	6410-5960	49.5-48.6	131-125	126-116
Average		6	1230 (7)	1720 (7)	6650 (7)			133 (7)	133 (7)
Range			1530-660	1820-1630	6950-6390			137-128	137-128
Tin									
Average	3		1450 (7)	2370 (7)		6560 (7)	47.7 (7)		143 (7)
Range			1950-1150	2460-2260		6950-6020	48.3-46.8		146-139
Average	6		1110 (7)	2820 (7)	7580 (3)	7240 (4)	48.2 (4)	174 (3)	167 (4)
Range			1510-738	2850-2790	7770-7220	7560-6550	49.5-47.0	178-170	173-160
Average		3	1260 (7)	1690 (7)	6520 (5)	6520 (2)	49.2 (2)	135 (4)	131 (2)
Range			1490-1100	1940-1600	6800-5890	6660-6370	49.6-48.7	144-128	134-127
Average		6	1030 (7)	1710 (7)	6290 (7)			125 (7)	
Range			1340-569	1860-1620	6760-5690			133-118	

(Figures in parenthesis are the number of observations)

TABLE X (contd)

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 to Produce 50% Comp	Work ft lbs/in^3 to Produce Rupture
Aluminum									
Average	3		1160 (7)	2320 (7)		6360 (7)	47.7 (7)		140 (7)
Range			1420-1040	2410-2220		6730-5590	49.0-46.0		150-128
Average	6		1150 (7)	2780 (7)		7370 (7)	48.5 (7)		164 (7)
Range			1620-762	2910-2680		7600-7210	49.5-47.4		168-162
Average		3	978 (7)	1590 (7)	5960 (6)	6000 (1)	48.2 (1)	125 (6)	117 (1)
Range			1200-747	1700-1510	6240-5620	6000-6000	48.2-48.2	131-118	117-117
Average		6	1050 (7)	1730 (7)	6520 (7)		131 (7)		
Range			1240-807	1800-1700	6810-574		136-126		
Magnesium									
Average	3		1450 (7)	2400 (7)		6710 (7)	46.8 (7)		143 (7)
Range			1680-1330	2440-2370		6900-6530	47.7-45.3		146-141
Average	6		1100 (7)	2880 (7)		7740 (3)	48.7 (3)	180 (4)	173 (3)
Range			1600-656	2940-2780		7940-7600	49.7-47.4	185-177	174-173
Average		3	1030 (7)	1640 (7)	6140 (7)			126 (7)	
Range			1220-639	1660-1600	6630-5540			133-116	
Average		6	1180 (7)	1700 (7)	6360 (7)			128 (7)	
Range			1450-426	1810-1610	6690-5920			134-121	
Varnish									
Average	3		1280 (7)	2280 (7)		6310 (7)	46.8 (7)		136 (7)
Range			1680-1030	2340-2240		6780-5770	49.2-45.6		148-125
Average	6		1520 (7)	2780 (7)		7310 (7)	48.3 (7)		167 (7)
Range			1720-1410	2830-2740		7620-7190	49.1-47.5		171-162
Average		3	866 (7)	1650 (7)	6003 (4)	6120 (3)	48.7 (3)	129 (4)	125 (3)
Range			1110-554	1720-1610	6110-5600	6230-6030	49.1-48.1	134-122	125-124
Average		6	1350 (7)	2110 (7)	6960 (5)	6980 (2)	48.2 (2)	148 (5)	147 (2)
Range			2150-822	2270-1940	7230-6810	7180-6770	48.8-47.5	153-141	155-138

(Figures in parenthesis are the number of observations)

TABLE X (contd)

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 to Produce 50% Comp	Work ft lbs/in^3 to Produce Rupture
Glass									
Average	3		1170 (7)	2250 (7)		6280 (7)	47.2 (7)		137 (7)
Range			1440-1040	2300-2210		6510-5770	48.8-44.9		148-129
Average	6		1460 (7)	2640 (7)	7390 (1)	7330 (6)	46.9 (6)	169 (1)	162 (6)
Range			1740-1130	2760-2530	7390-7390	7420-7060	49.7-46.7	169-169	169-147
Average		3	1040 (7)	1560 (7)	5970 (6)	5880 (1)	48.8 (1)	124 (6)	115 (1)
Range			1220-753	1660-1450	6380-5630	5880-5880	48.8-48.8	127-121	115-115
Average		6	724 (7)	6970 (7)	6970 (7)		136 (7)		
Range			914-381	1860-1680	7410-6160		138-129		

(Figures in parenthesis are the number of observations)

TABLE XI

COMPRESSIVE PROPERTIES OF M-13 PROPELLANT AT 32°C

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 To Produce 50% Comp	Work ft lbs/in^3 To Produce Rupture
Control									
Average	0	0	804 (5)	1250 (5)	3700 (2)	3610 (3)	47.7 (3)	87.2 (2)	78.9 (3)
Range			948-725	1290-1160	3810-3590	3700-3530	48.4-46.9	89.5-85.0	82.0-76.4
Zinc									
Average	3		843 (6)	1440 (6)		3530 (6)	47.8 (6)		87.2 (6)
Range			978-613	1620-1310		3820-3250	48.7-46.8		92.7-78.8
Average	6		791 (6)	1790 (6)	4530 (3)	4150 (3)	48.8 (3)	113 (3)	100 (3)
Range			981-650	1920-1570	4710-4370	4380-3900	49.7-48.3	117-110	
Average		3	791 (7)	1150 (7)	3550 (5)	3790 (2)	48.9 (2)	80.5 (5)	80.2 (2)
Range			940-697	1240-1050	3720-3260	3960-3620	49.0-48.7	85.6-74.8	81.5-78.8
Average		6	574 (7)	1020 (7)	3300 (6)			73.3 (6)	
Range			761-519	1170-916	3600-2990			83.1-66.4	
Stainless Steel									
Average	3		788 (7)	1500 (7)	3610 (1)	3730 (6)	47.9 (6)	91.9 (1)	93.5 (6)
Range			1010-582	1720-1340	3610-3610	4300-3470	49.4-46.3	91.9-91.9	102-86.4
Average	6		804 (6)	1830 (6)	4510 (2)	4220 (4)	48.4 (4)	113 (2)	103 (4)
Range			905-640	1900-1730	4610-4410	4360-4060	48.9-47.8	113-112	104-101
Average		3	810 (7)	1120 (7)	3370 (2)	3520 (5)	49.6 (5)	75.9 (2)	79.3 (5)
Range			969-685	1220-1030	3400-3330	3540-3220	49.9-48.7	76.0-75.8	85.3-73.9
Average		6	702 (7)	1030 (7)	3540 (6)	3760 (1)	49.6 (1)	73.9 (6)	73.6 (1)
Range			784-661	1120-924	3710-3230	3760-3760	49.6-49.6	77.4-69.2	73.6-73.6
Tin									
Average	3		775 (7)	1460 (7)	3820 (2)	3590 (5)	45.6 (5)	97.1 (2)	85.9 (5)
Range			1050-548	1590-1210	3880-3750	4010-3410	48.2-36.3	99.7-94.4	96.4-76.0
Average	6		945 (6)	1770 (6)	4320 (4)	4290 (2)	47.7 (2)	109 (4)	99.5 (2)
Range			1020-737	1830-1710	4440-4190	4580-4000	48.1-47.2	113-107	102-969
Average		3	643 (7)	1110 (7)	3500 (4)	3570 (3)	49.9 (3)	80.7 (4)	80.2 (3)
Range			721-583	1240-946	3790-3140	3780-3460	50.1-49.8	87.9-72.0	87.4-72.2
Average		6	656 (6)	1050 (6)	3720 (6)			72.8 (6)	
Range			855-589	1160-949	4510-3310			84.3-60.2	

(Figures in parenthesis are the number of observations)

TABLE XI (contd)

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 To Produce 50% Comp	Work ft lbs/in^3 To Produce Rupture
Aluminum									
Average	3		705 (7)	1410 (7)	3640 (5)	3520 (2)	48.2 (2)	91.1 (5)	84.4 (2)
Range			820-508	1470-1320	3850-3290	3710-3320	48.3-48.1	96.3-82.0	85.8-83.0
Average	6		717 (7)	1640 (7)	4280 (6)	4320 (1)	49.5 (1)	97.7 (6)	101 (1)
Range			982-526	1780-1560	4970-3950	3220-4320	49.5-49.5	104-81.8	101-101
Average		3	749 (7)	1110 (7)	3550 (5)	3560 (20)	49.7 (2)	78.9 (5)	79.1 (2)
Range			870-676	1220-1070	4160-3260	3810-3310	49.9-49.5	91.6-73.4	81.2-76.9
Average		6	573 (7)	917 (7)	3250 (7)			67.4 (7)	
Range			680-537	1040-812	3730-2880			75.6-59.3	
Magnesium									
Average	3		980 (7)	1470 (7)	3660 (2)	3610 (5)	47.8 (5)	92.7 (2)	88.1 (5)
Range			1050-868	1550-1450	3710-3600	3860-3350	49.3-45.7	97.6-87.7	103-78.5
Average	6		885 (6)	1790 (6)	4270 (2)	4250 (4)	48.8 (4)	107.5 (2)	105 (4)
Range			1040-699	1870-1740	4310-4220	4500-4220	49.3-48.5	109-106	106-104
Average		3	747 (7)	1110 (7)	3410 (4)	3420 (3)	49.0 (3)	78.4 (4)	76.4 (3)
Range			819-662	1240-946	3670-3150	3620-3270	49.3-48.8	84.5-70.9	81.0-73.9
Average		6	645 (7)	990 (7)	3440 (7)			72.9 (7)	
Range			708-580	1030-929	3860-3000			77.4-66.7	
Varnish									
Average	3		814 (7)	1280 (7)	3400 (1)	3590 (6)	47.6 (6)	83.1 (1)	78.2 (6)
Range			1020-652	1350-1140	3400-3400	4670-3130	48.3-46.7	83.1-83.1	83.9-71.1
Average	6		815 (7)	1640 (7)	3740 (2)	4170 (5)	48.2 (5)	92.1 (2)	98.4
Range			1060-596	1840-1460	3850-3630	4580-3710	48.7-47.5	96.0-88.2	104-89.8
Average		3	790 (7)	1050 (7)	3350 (5)	3630 (2)	48.8 (2)	74.7 (5)	77.6 (2)
Range			856-726	1130-966	3510-3180	3810-3450	48.8-48.7	77.6-71.1	79.8-75.3
Average		6	607 (7)	1010 (7)	3430 (7)			72.8 (7)	
Range			700-469	1090-950	3740-3100			76.6-66.3	

(Figures in parenthesis are the number of observations)

TABLE XI (contd)

Storage Material	Storage Period, mos: 90% RH	Storage Period, mos: Desiccated	Stress in psi at: 1% Comp	Stress in psi at: 5% Comp	Stress in psi at: 50% Comp	Stress in psi at: Rupture	Compression at Rupture, %	Work ft lbs/in^3 To Produce: 50% Comp	Work ft lbs/in^3 To Produce: Rupture
Glass									
Average	3		751 (7)	1310 (7)	3610 (3)	3450 (4)	48.8 (4)	87.0 (3)	80.5 (4)
Range			1000-557	1416-1150	3760-3470	3700-3190	49.5-48.3	87.8-86.2	91.4-73.7
Average	6		849 (7)	1670 (7)	3710 (1)	3810 (6)	47.7 (5)	98.9 (1)	93.9 (6)
Range			1070-666	1750-1610	3710-3710	4160-3660	49.3-45.1	98.9-98.9	96.6-91.8
Average		3	714 (7)	1140 (7)	3830 (7)			81.7 (7)	
Range			817-662	1230-1040	3980-3570			85.8-77.6	
Average		6	777 (7)	1280 (7)	4260 (7)			89.9 (7)	
Range			998-692	1370-1150	4560-4070			94.4-82.6	

(Figures in parenthesis are the number of observations)

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TABLE XII

COMPRESSIVE PROPERTIES OF T-7 PROPELLANT AT 32°C

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in³ To Produce 50% Comp	Work ft lbs/in³ To Produce Rupture
Control									
Average	0	0	2720 (5)	4780 (5)		4890 (5)	6.04 (5)		19.0 (5)
Range	0	0	3130-1930	5510-4410		5630-4530	6.28-5.31		22.6-16.9
Zinc									
Average	3		2110 (7)	5880 (2)		5970 (7)	4.81 (7)		15.8 (7)
Range			3040-1830	6270-5490		6300-5510	5.20-4.60		18.4-14.5
Average	6		1930 (7)			6980 (7)	4.34 (7)		16.0 (7)
Range			2550-1390			7300-6680	4.87-3.85		18.9-13.9
Average		3	1570 (7)	4520 (7)		4700 (7)	6.13 (7)		17.0 (7)
Range			1860-1250	4870-4090		5110-4330	6.41-5.55		19.8-15.6
Average		6	1800 (7)	4570 (7)		4820 (7)	6.55 (7)		19.2 (7)
Range			2440-1250	5180-4300		5280-4530	7.61-5.80		22.1-16.9
Stainless Steel									
Average	3		2160 (7)	5910 (3)		6000 (7)	5.00 (7)		16.6 (7)
Range			3300-1360	6290-5340		6400-5530	5.33-4.75		20.0-16.0
Average	6		3160 (7)	7080 (3)		7230 (7)	4.64 (7)		19.6 (7)
Range			4090-2280	7340-6690		7560-6720	5.41-3.82		23.0-15.5
Average		3	1710 (7)	4470 (7)		4630 (7)	6.02 (7)		16.3 (7)
Range			2440-1180	5060-4030		5150-4360	6.49-5.74		17.0-15.1
Average		6	1450 (7)	4440 (7)		4730 (7)	6.59 (7)		18.2 (7)
Range			1810-1190	4650-4320		4900-4550	7.11-5.87		21.5-14.9
Tin									
Average	3		2720 (7)	6120 (3)		5990 (7)	4.76 (7)		17.0 (7)
Range			3230-2190	6310-5920		6310-5680	5.36-4.18		19.6-13.9
Average	6		3060 (7)			7280 (7)	3.98 (7)		15.9 (7)
Range			4480-2150			7840-6490	4.48-3.04		20.4-12.5
Average		3	1640 (7)	4480 (7)		4720 (7)	6.25 (7)		16.9 (7)
Range			2100-1260	4710-4270		5100-4360	6.92-5.75		18.6-14.6
Average		6	1680 (7)	4570 (7)		4790 (7)	6.22		18.2 (7)
Range			2730-1020	4950-4290		5010-4430	7.78-5.01		21.7-16.4

(Figures in parenthesis are the number of observations)

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TABLE XII (contd)

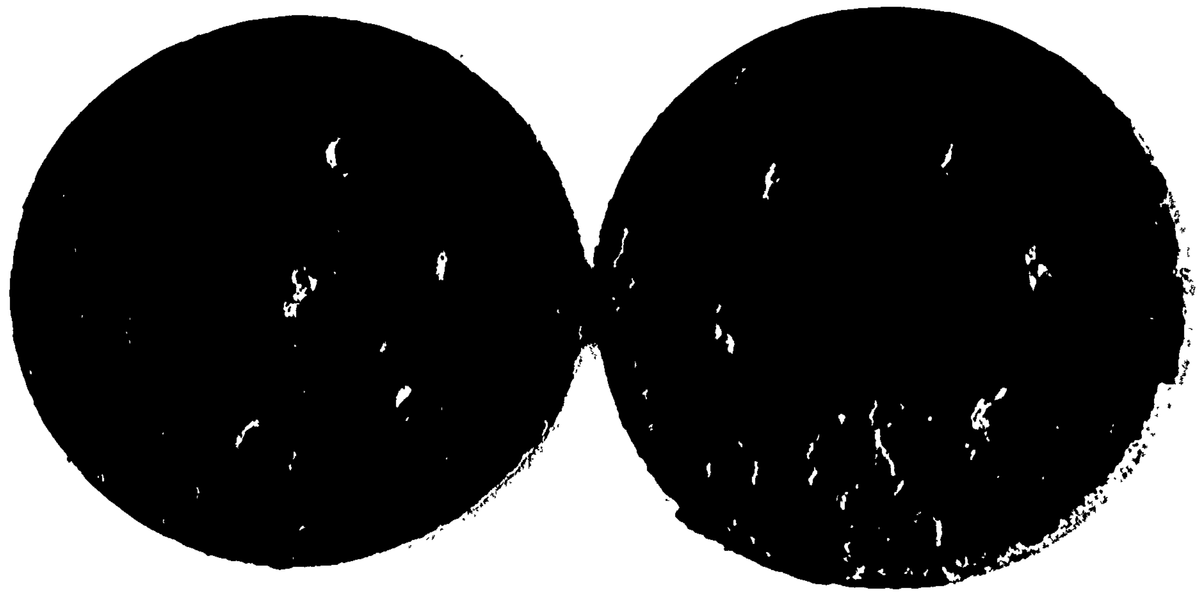
Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desiccated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 To Produce 50% Comp	Work ft lbs/in^3 To Produce Rupture
Aluminum									
Average	3		3540 (7)	6480 (2)		6530 (7)	4.65 (7)		18.7 (7)
Range			4180-2730	6550-6400		6850-6290	5.18-3.99		20.7-16.3
Average	6		3650 (7)			8340 (7)	3.99 (7)		18.9 (7)
Range			4240-2650			8640-7580	4.32-3.86		22.9-16.4
Average		3	1720 (7)	4060 (7)		4390 (7)	6.68		17.2 (7)
Range			2040-1500	4390-3920		4630-4280	7.56-6.00		19.0-14.2
Average		6	1420 (7)			4820 (7)	6.48		17.7 (7)
Range			2260-916	5280-4140		5490-4470	7.62-5.50		20.4-15.4
Magnesium									
Average	3		2020 (7)	5740 (4)		5950 (7)	5.22 (7)		17.8 (7)
Range			2860-1510	6390-5150		6480-5470	7.03-4.41		23.1-14.4
Average	6		2830 (7)			7540 (7)	4.05 (7)		16.2 (7)
Range			4290-1770			8410-6570	4.38-3.83		18.1-13.5
Average		3	1900 (7)	4650 (7)		4820 (7)	6.13 (7)		17.3 (7)
Range			2450-1330	5010-4190		5080-4410	6.64-5.58		18.4-16.6
Average		6	1590 (7)	4810 (7)		5090 (7)	6.47 (7)		19.0 (7)
Range			2450-1050	5490-4390		5620-4720	6.99-6.09		22.1-16.2
Varnish									
Average	3		3280 (7)	6530 (2)		6530 (7)	4.69 (7)		18.7 (7)
Range			4460-1970	6610-6450		6770-6410	5.11-4.15		20.8-16.7
Average	6		4100 (7)			7860 (7)	3.97 (7)		18.5 (7)
Range			5070-1880			8210-7120	4.34-3.68		21.0-15.4
Average		3	1970 (7)	4560 (7)		4790 (7)	6.35 (7)		18.6 (7)
Range			2710-1320	5080-4250		5260-4550	6.86-5.93		19.3-17.7
Average		6	1670 (7)	5020 (7)		5290 (7)	6.33 (7)		19.0 (7)
Range			3230-740	5400-4660		5560-4910	6.96-5.41		20.3-16.7

(Figures in parenthesis are the number of observations)

TABLE XII (contd)

Storage Material	Storage Period, mos 90% RH	Storage Period, mos Desic-cated	Stress in psi at 1% Comp	Stress in psi at 5% Comp	Stress in psi at 50% Comp	Stress in psi at Rupture	Compression at Rupture, %	Work ft lbs/in^3 To Produce 50% Comp	Work ft lbs/in^3 To Produce Rupture
Glass									
Average	3		2590 (7)	6190 (7)		6250 (7)		5.34 (7)	19.7 (7)
Range			3100-1420	6390-5890		6420-5890		6.11-4.98	22.5-17.8
Average	6		3600 (7)			7690 (7)			20.3 (7)
Range			4190-2770			8020-7330			24.9-16.8
Average		3	2560 (7)	4720 (7)		4880 (7)	6.06 (7)		18.8 (7)
Range			2990-2090	5250-4530		5310-4670	6.51-5.48		21.1-16.0
Average		6	2930 (7)	5170 (7)		5250 (7)	5.86 (7)		19.1 (7)
Range			3410-2550	5750-4800		5780-4890	6.54-5.34		21.8-17.7

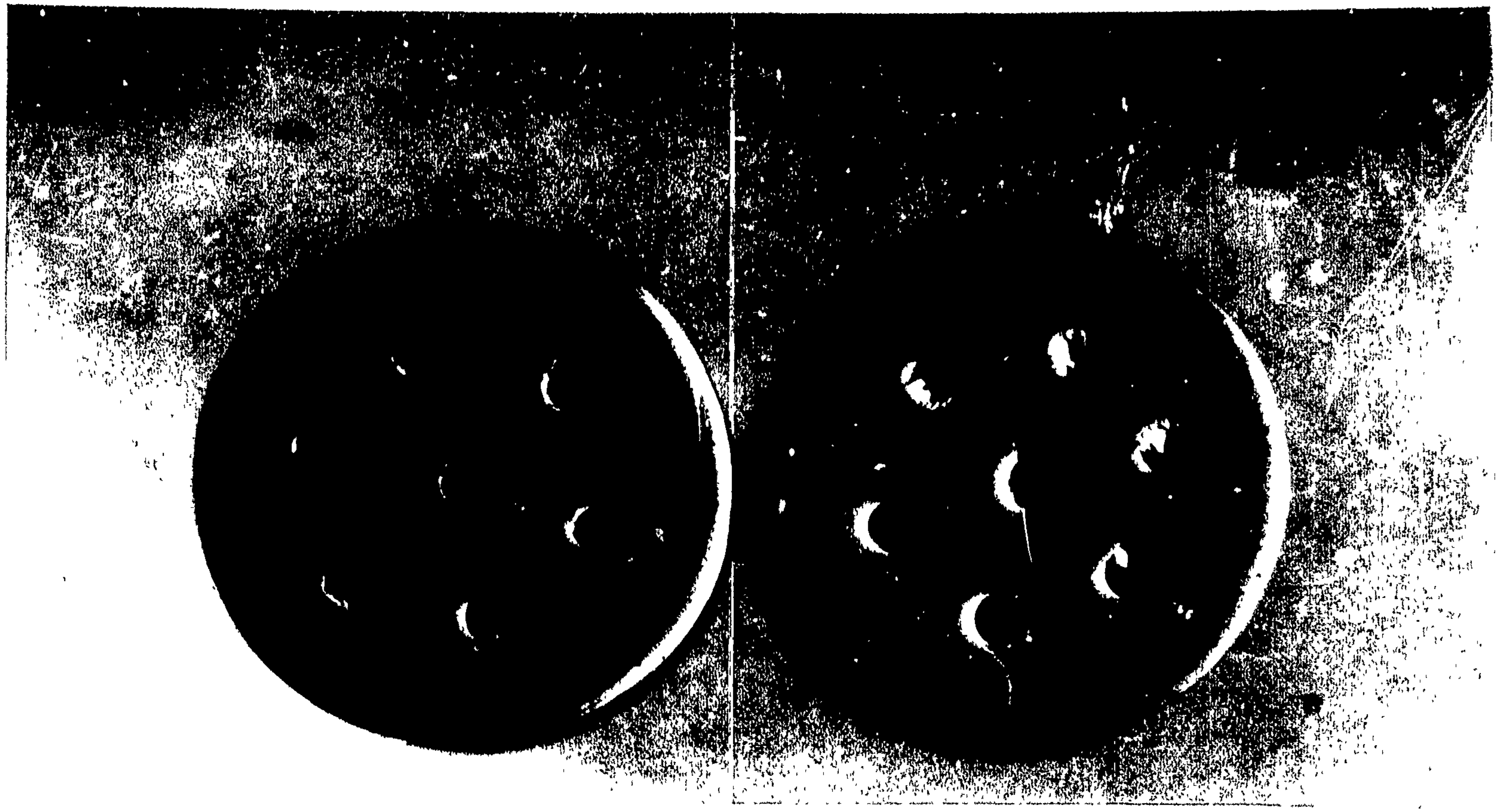
(Figures in parenthesis are the number of observations)



M-39362 July 1951 PICATINNY ARSENAL ORDNANCE CORPS

Fig. 1

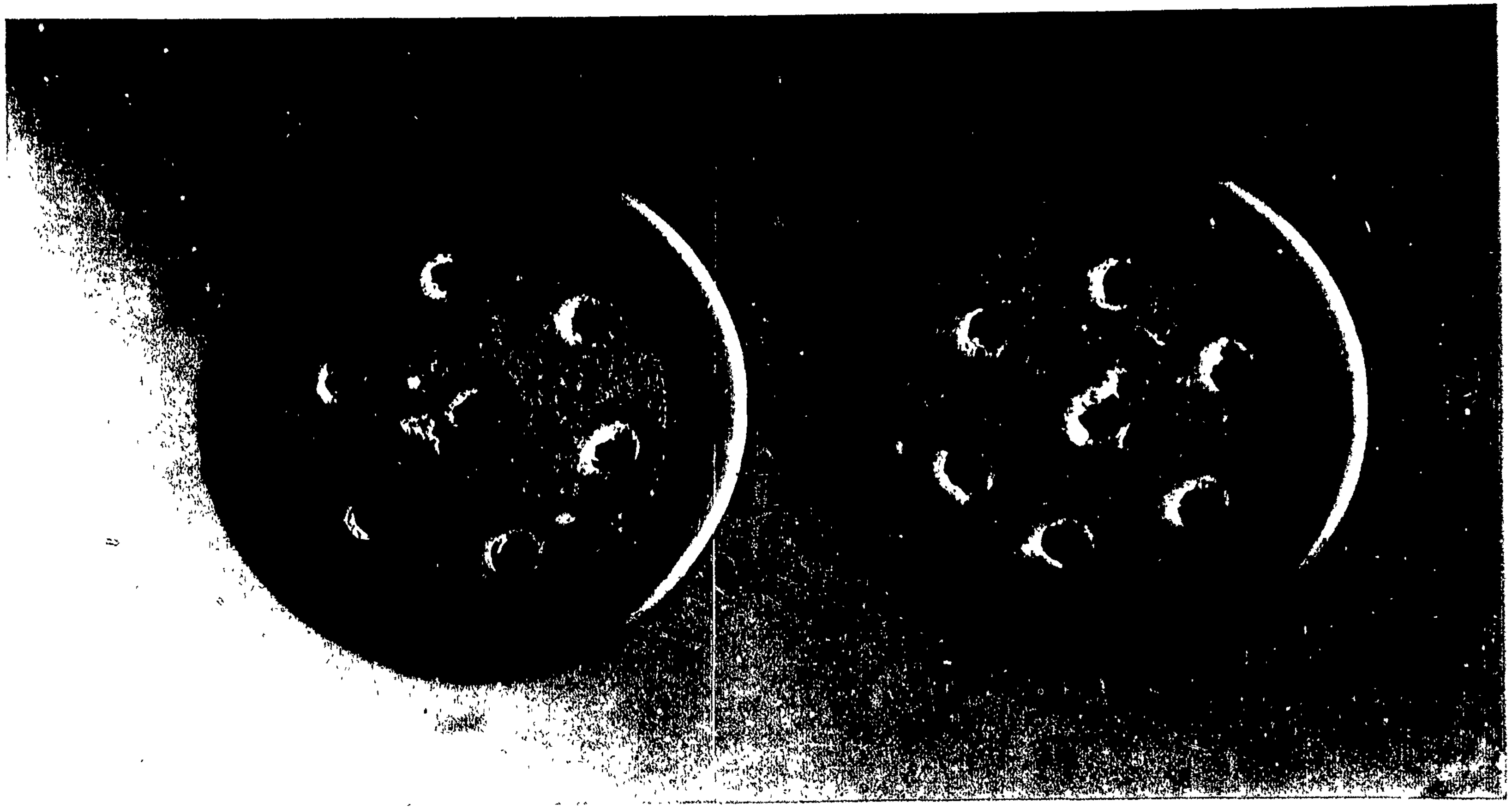
Grains of T7 Propellant Stored In Contact With Magnesium For Six Months At 32°C And 90% Relative Humidity.



M-39362/1 July 1951 PICATINNY ARSENAL ORDNANCE CORPS

Fig. 2

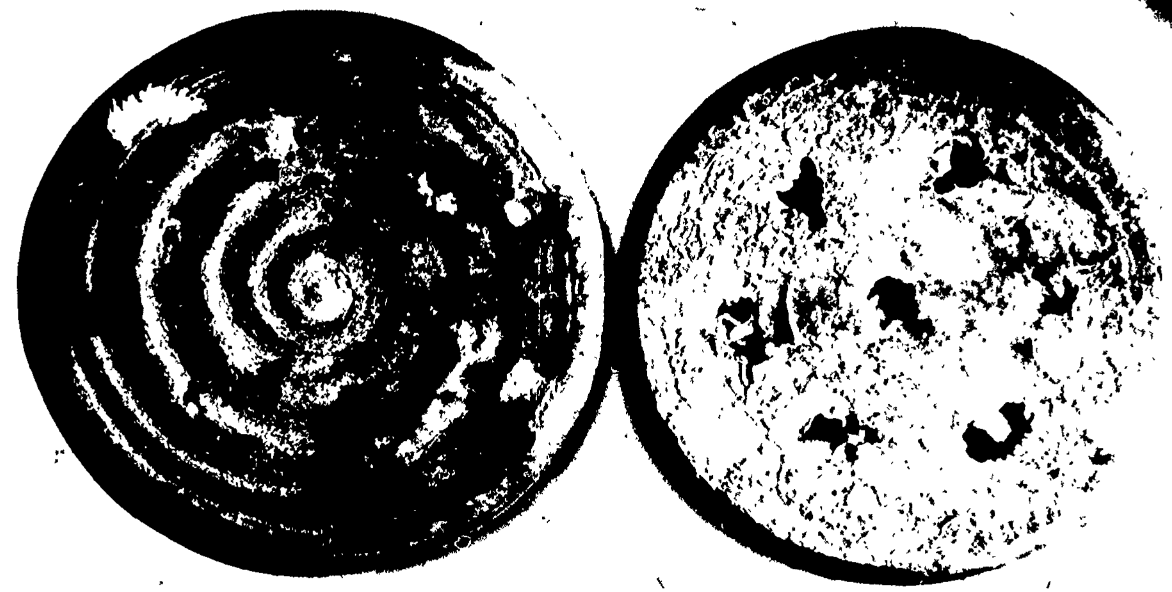
Grains of T7 Propellant Stored In Contact With Phenol Formaldehyde - Coated Steel For Six Months At 32°C and 90% Relative Humidity.



N-39362/2	July 1951	PICATINNY ARSENAL	ORDNANCE CORPS

Fig. 3

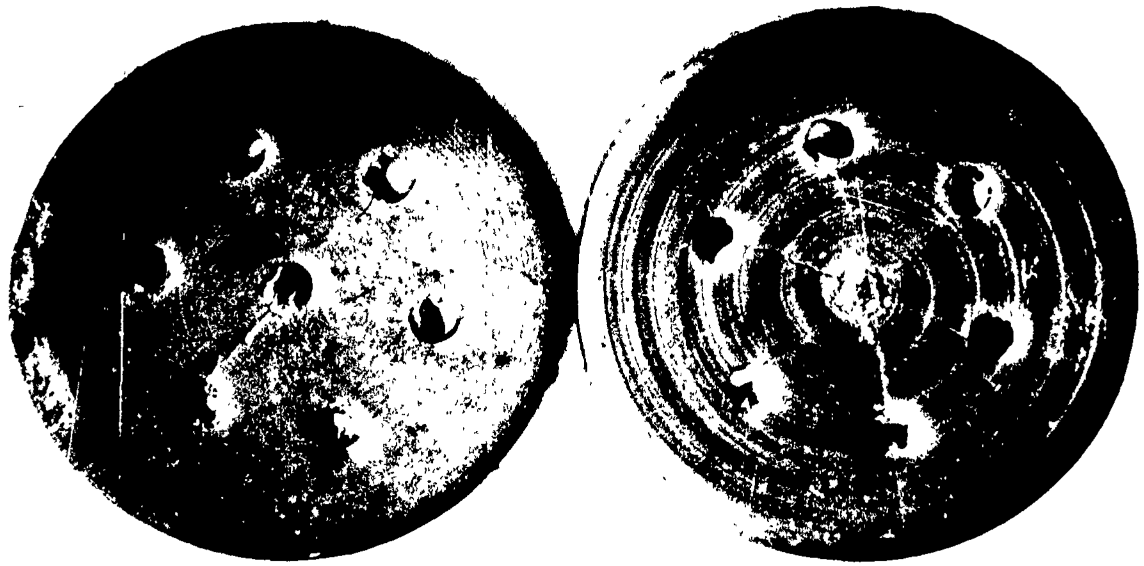
Grains of T7 Propellant Stored In Contact With Stainless Steel For Six Months At 32°C And 90% Relative Humidity.



M-39362/3 July 1951 PICATINNY ARSENAL ORDNANCE CORPS

Fig. 4

Grains of T7 Propellant Stored In Contact With Zinc Plated Steel
For Six Months at 32°C and 90% Relative Humidity.



M-39362/4 July 1951 PICATINNY ARSENAL ORDNANCE CORPS

Fig. 5

Grains of T7 Propellant Stored In Contact With Aluminum For Six Months at 32°C And 90% Relative Humidity.

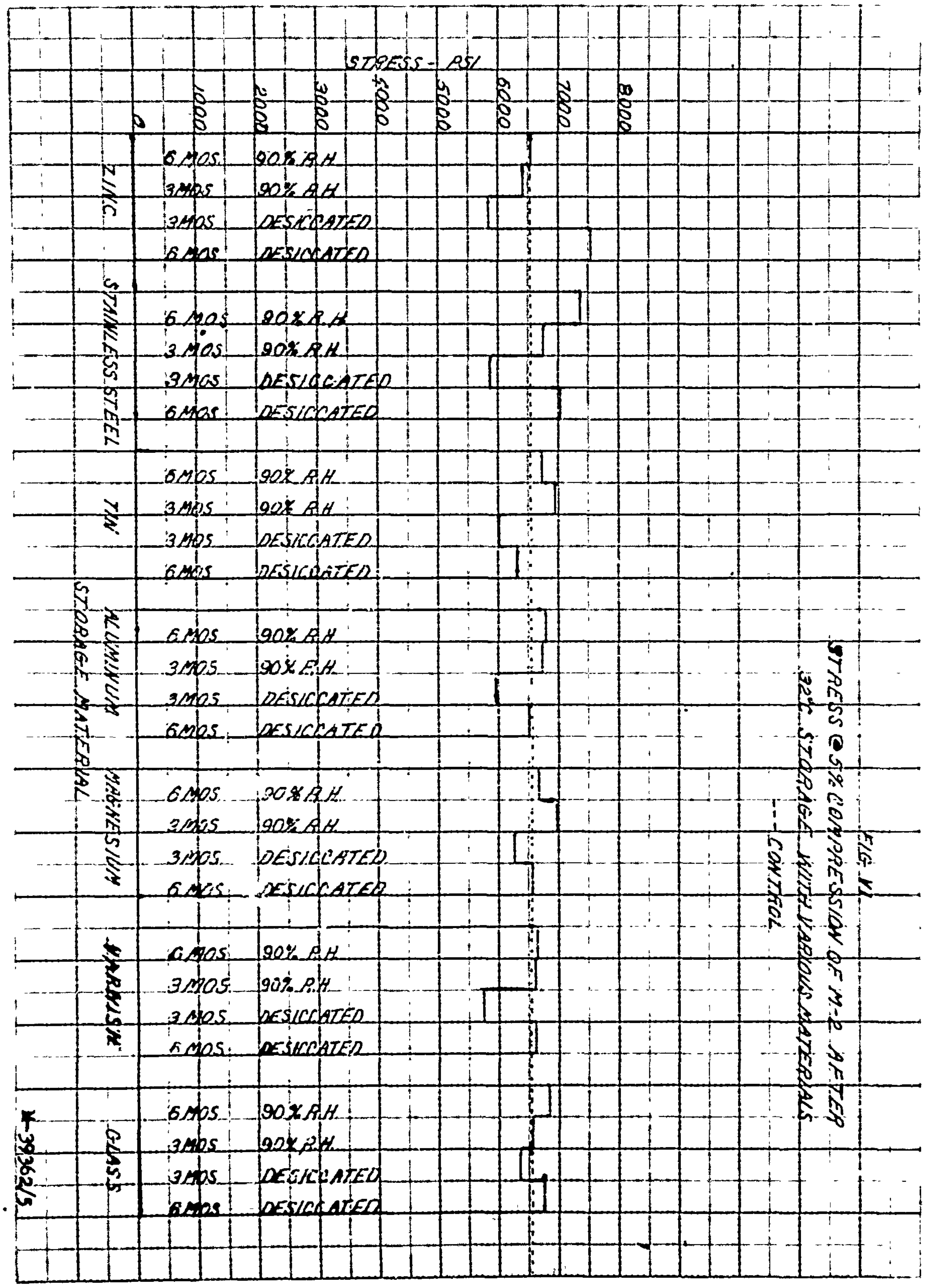


FIG. VI
STRESS @ 5% COMPRESSION OF M-2 AFTER 32°C STORAGE WITH VARIOUS MATERIALS

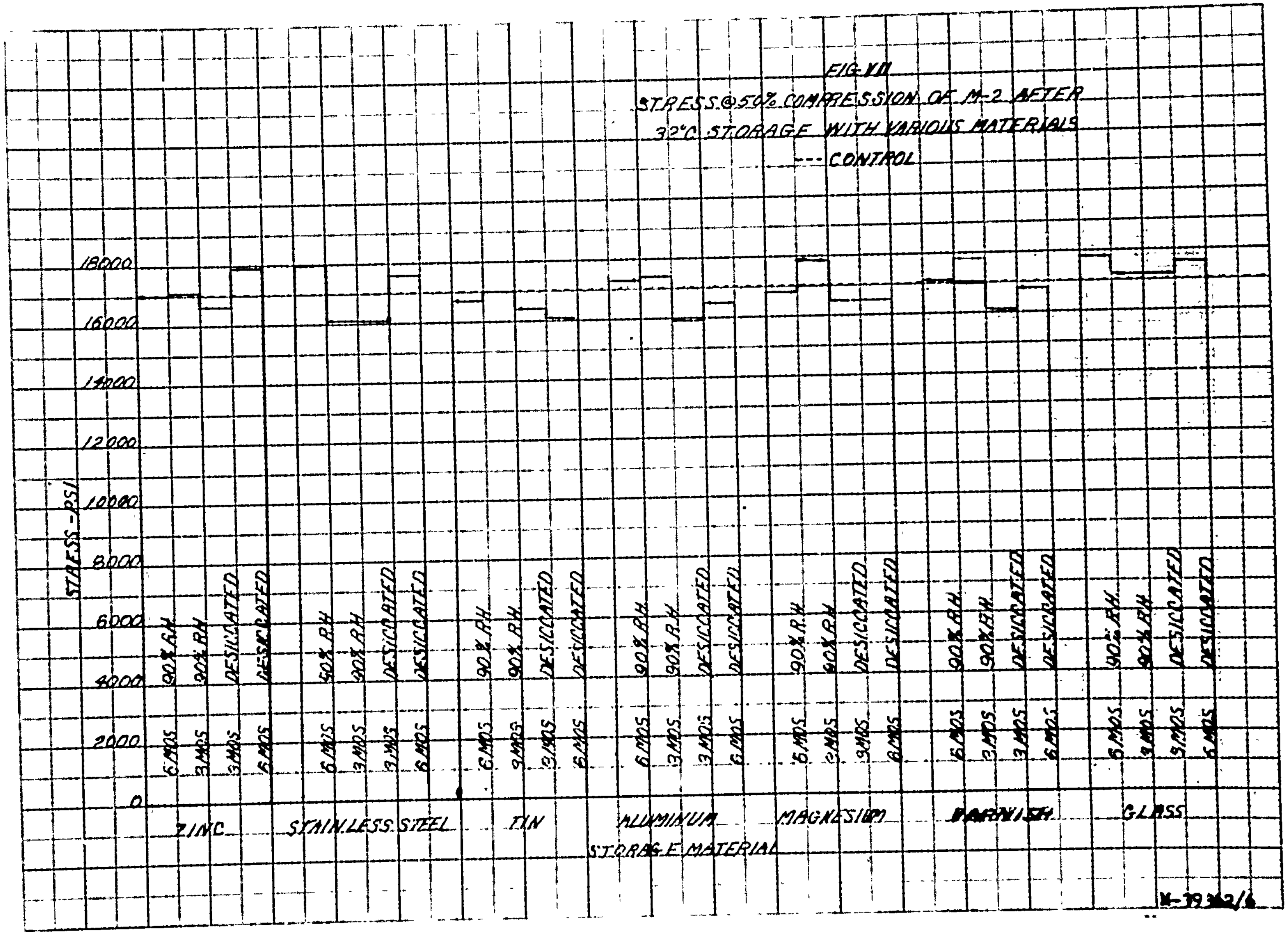


FIG XII
STRESS @ 50% COMPRESSION OF M-2 AFTER 32°C STORAGE WITH VARIOUS MATERIALS

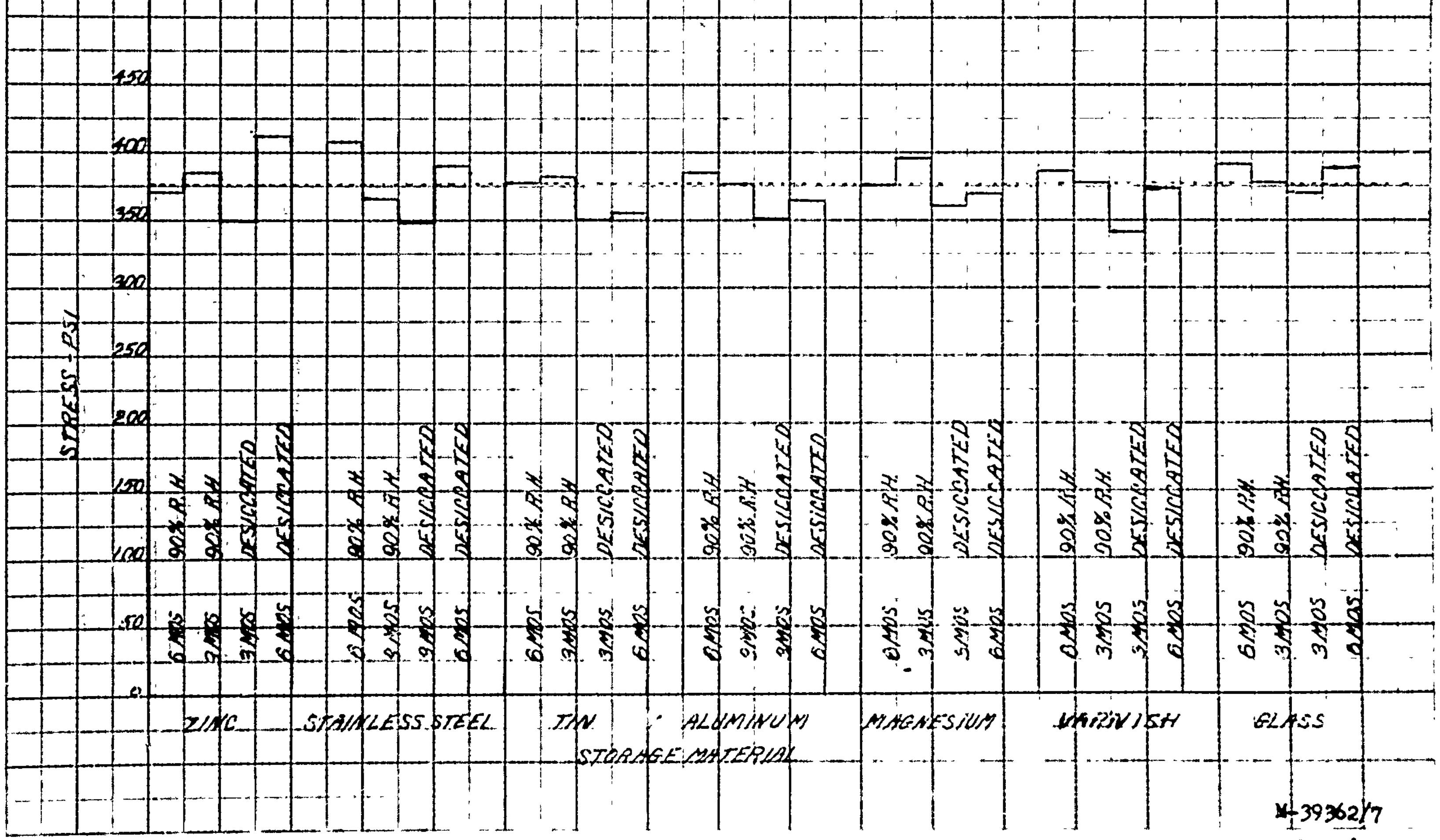


FIG XVII
WORK TO PRODUCE 50% COMPRESSION OF M-2 AFTER 32°C STORAGE WITH VARIOUS MATERIALS
---CONT'D

M-39362/7

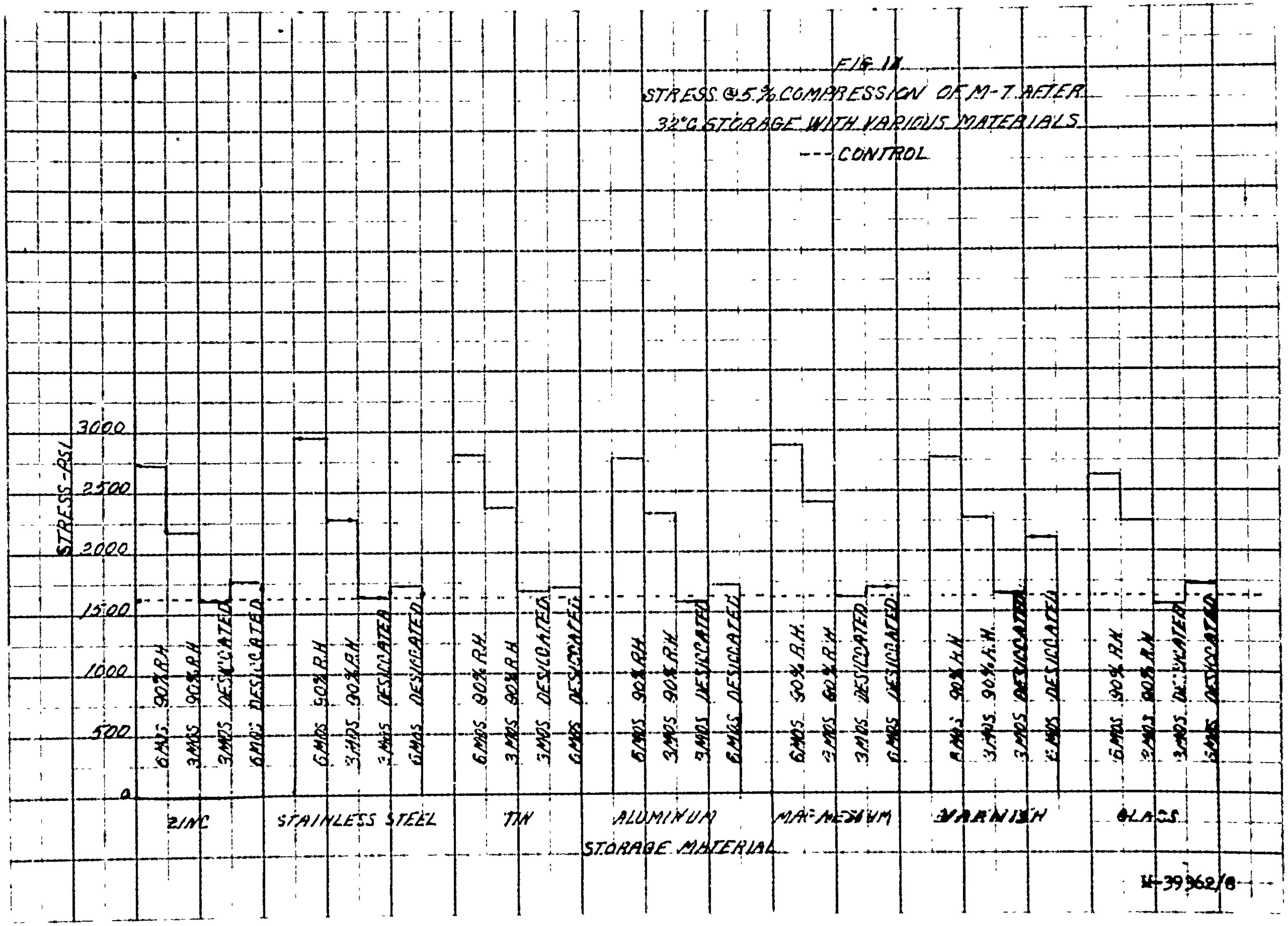
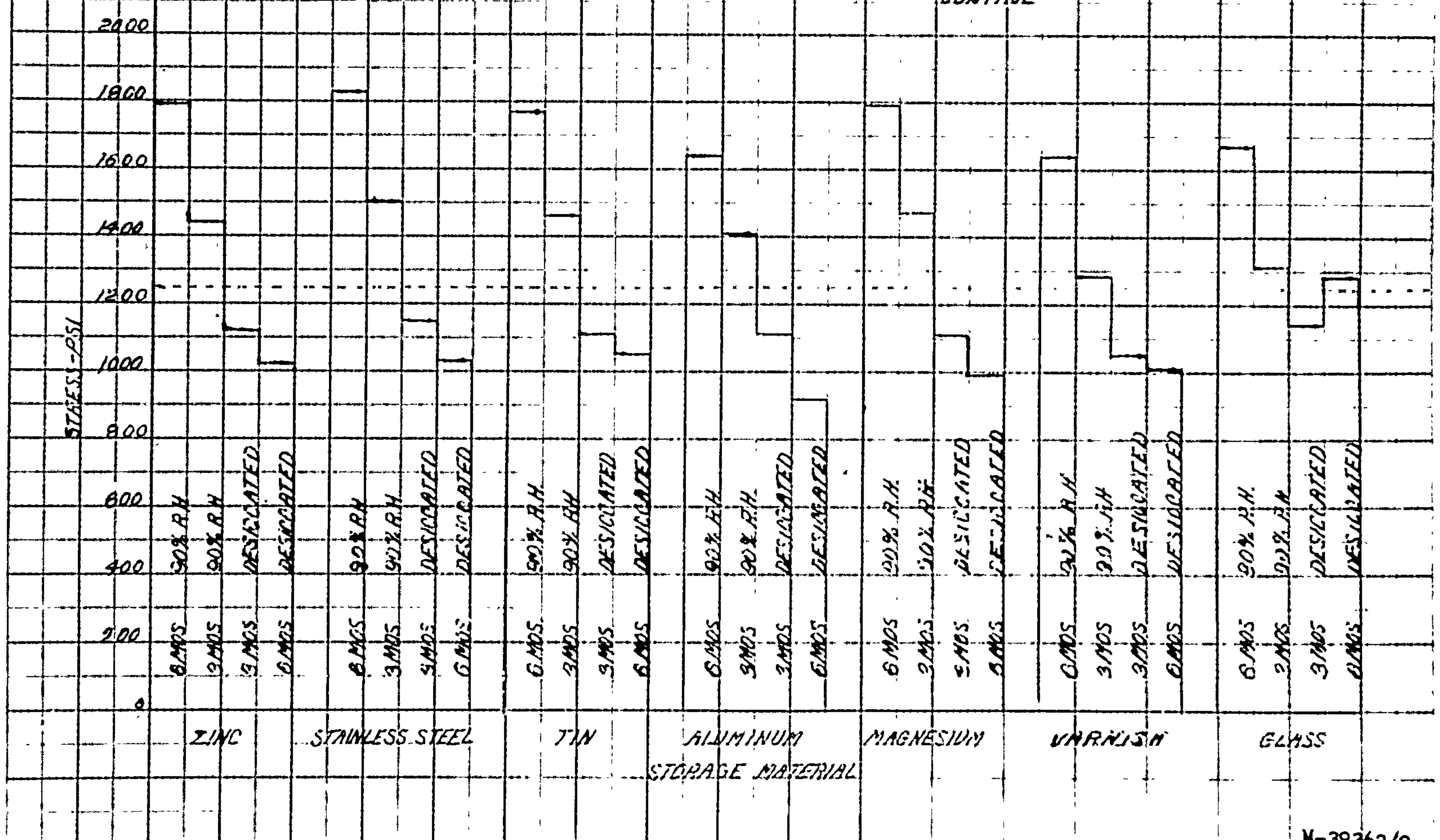


FIG 1X
STRESS @5% COMPRESSION OF M-7 AFTER
32°C STORAGE WITH VARIOUS MATERIALS

FIG. X

STRESS @ 5% COMPRESSION OF M-13 AFTER 32°C STORAGE WITH VARIOUS MATERIALS

--- CONTROL



M-39362/9

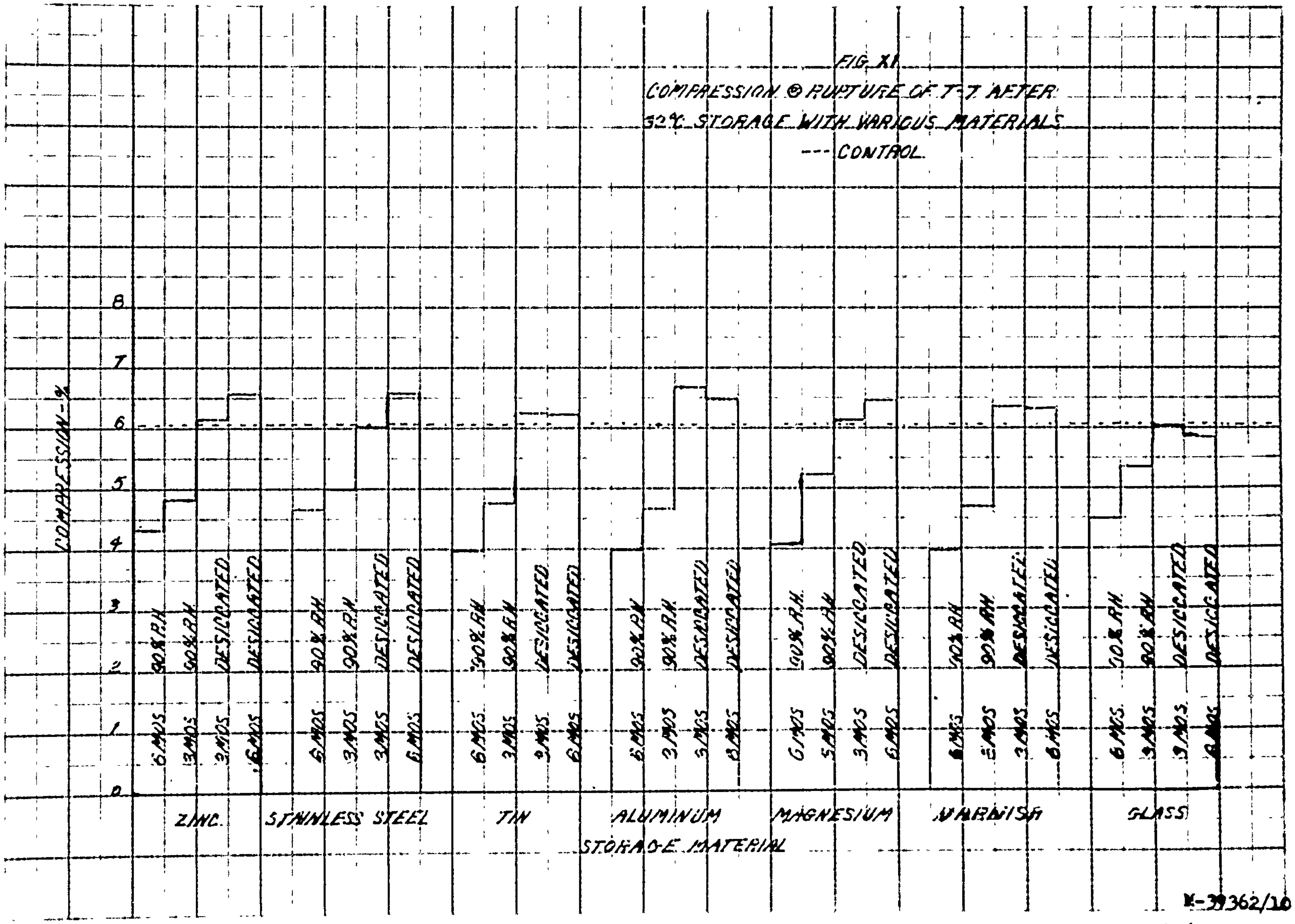


FIG. XI
COMPRESSION @ RUPTURE OF T-7 AFTER
32°C STORAGE WITH VARIOUS MATERIALS

K-39362/10

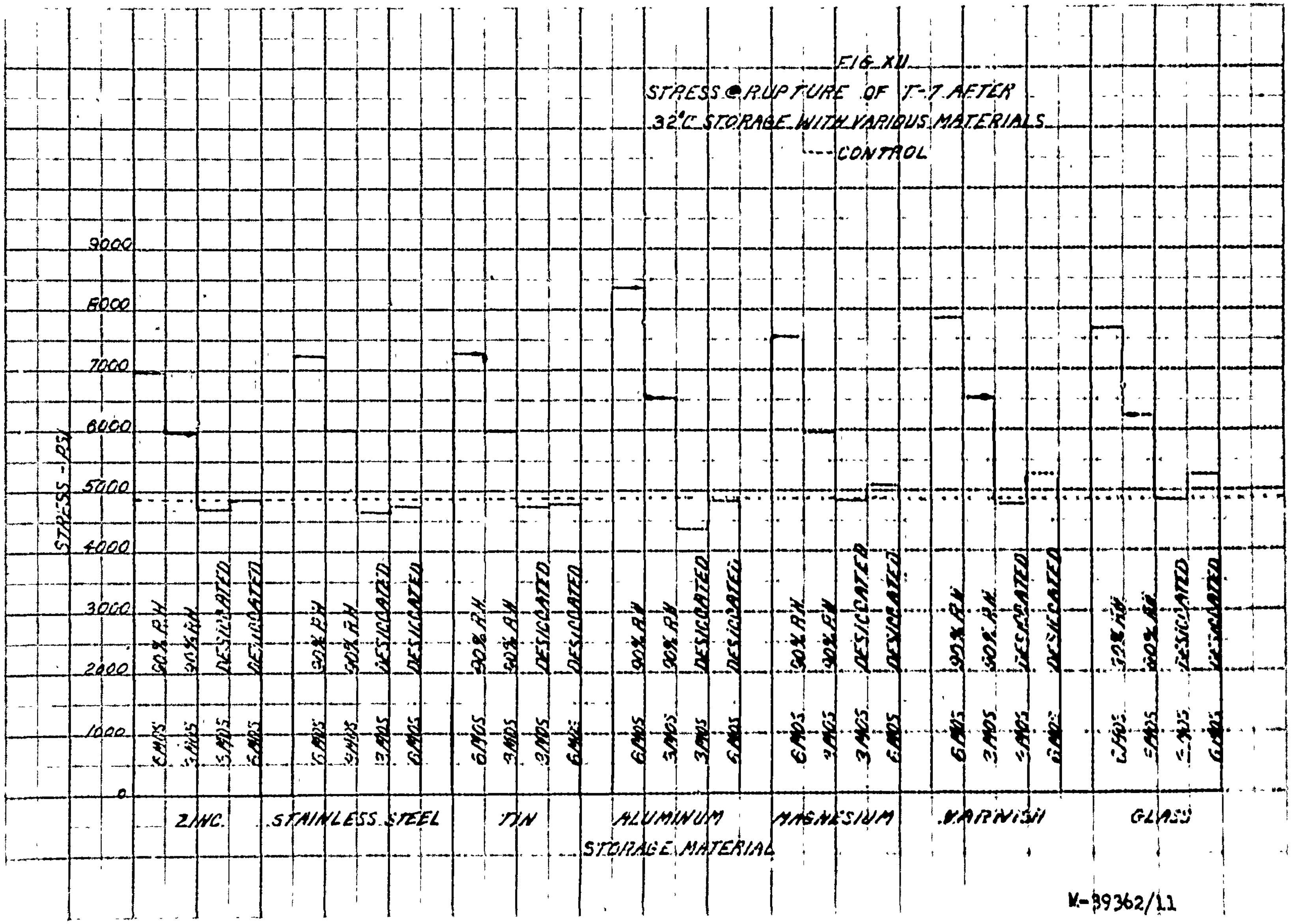


FIG. XII
STRESS @ RUPTURE OF T-7 AFTER
32°C STORAGE WITH VARIOUS MATERIALS
CONTROL
STRESS - PSI
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
6 MOS 90% R.H.
3 MOS 90% R.H.
3 MOS DESICCATED
6 MOS DESICCATED
ZINC
STAINLESS STEEL
TIN
ALUMINUM
MAGNESIUM
VARNISH
GLASS
STORAGE MATERIAL

K-39362/11

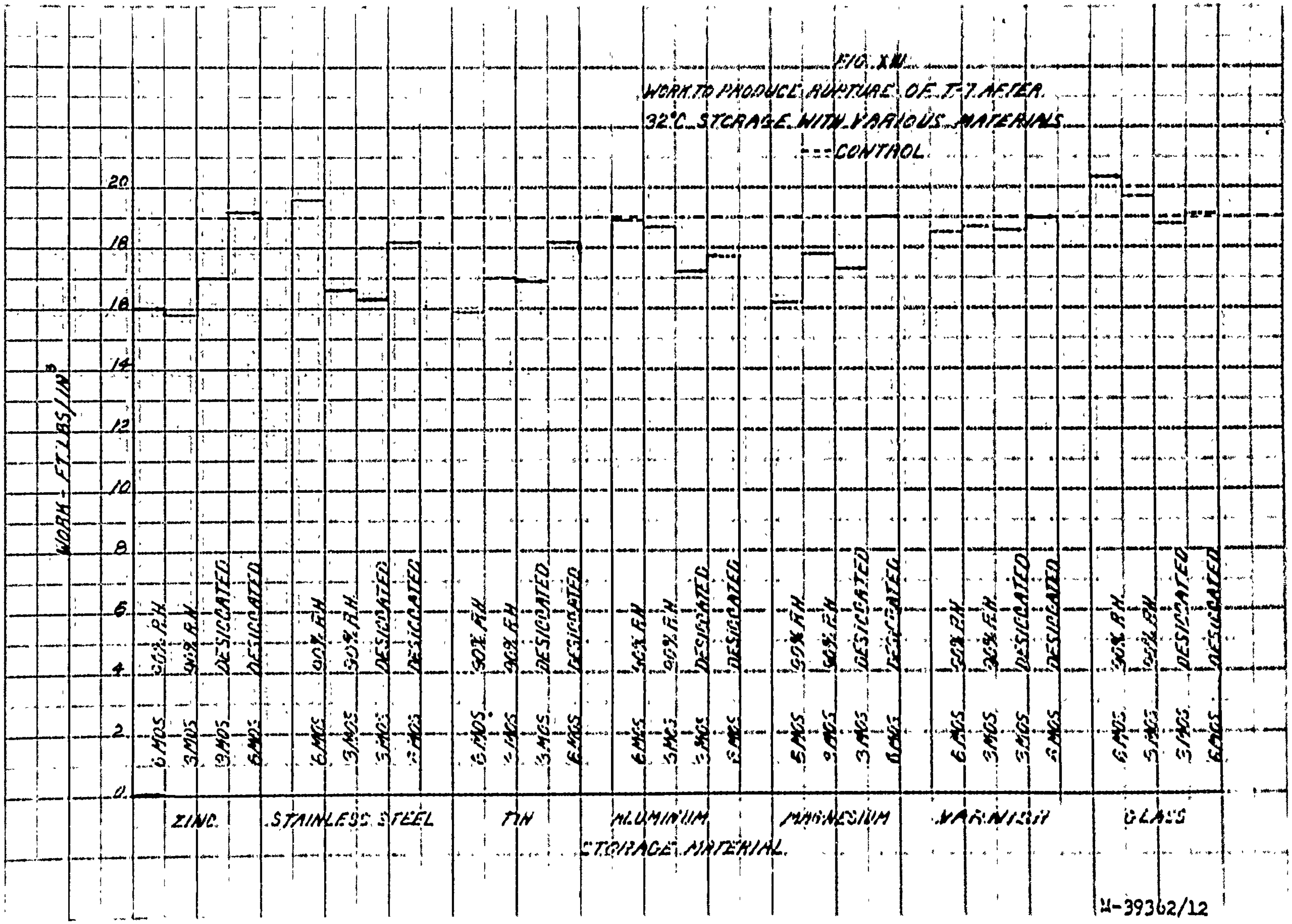
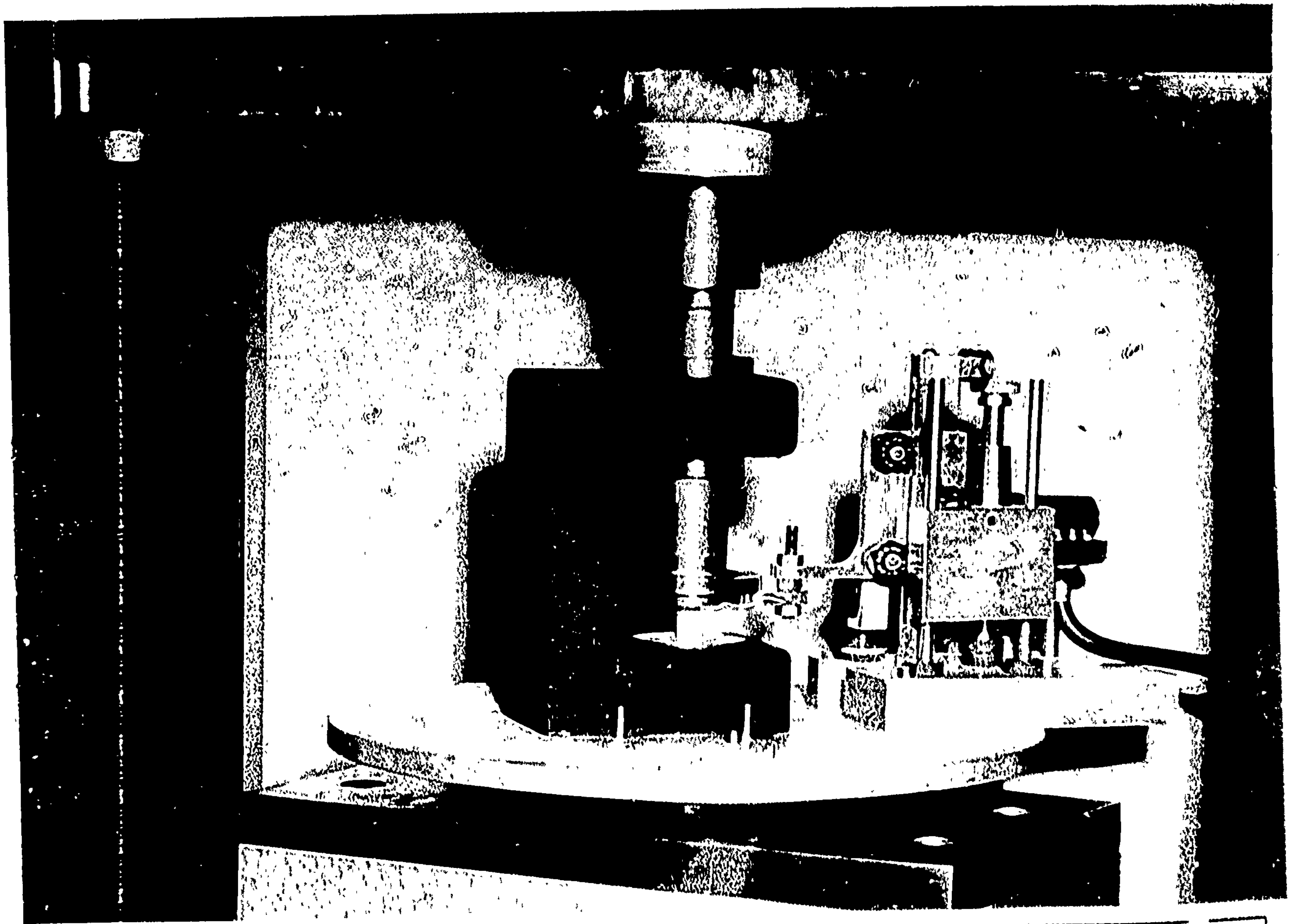


FIG. XIV.
WORK TO PRODUCE RUPTURE OF T-7 AFTER 32°C STORAGE WITH VARIOUS MATERIALS.

M-39362/12



M-38451 January 1951 PICATINNY ARSENAL ORDNANCE C...

Sub-Press and Compressometer Mounting on Compression Table